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APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
09/716,016	11/16/2000	Steven T. Mayer	M-7125-2D US	7163

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EXAMINER	
LEADER, WILLIAM T	
ART UNIT	PAPER NUMBER
1741	

DATE MAILED: 05/28/2002

Please find below and/or attached an Office communication concerning this application or proceeding.

MF-6

Office Action Summary	Application No.	Applicant(s)
	09/716,016	Mayer et al
	Examiner	Group Art Unit
	William Leader	1741

—The MAILING DATE of this communication appears on the cover sheet beneath the correspondence address—

Period for Response

A SHORTENED STATUTORY PERIOD FOR RESPONSE IS SET TO EXPIRE 3 MONTH(S) FROM THE MAILING DATE OF THIS COMMUNICATION.

- Extensions of time may be available under the provisions of 37 CFR 1.136(a). In no event, however, may a response be timely filed after SIX (6) MONTHS from the mailing date of this communication.
- If the period for response specified above is less than thirty (30) days, a response within the statutory minimum of thirty (30) days will be considered timely.
- If NO period for response is specified above, such period shall, by default, expire SIX (6) MONTHS from the mailing date of this communication .
- Failure to respond within the set or extended period for response will, by statute, cause the application to become ABANDONED (35 U.S.C. § 133).

Status

☐ Responsive to communication(s) filed on _____.

☐ This action is **FINAL.**

☐ Since this application is in condition for allowance except for formal matters, **prosecution as to the merits is closed** in accordance with the practice under *Ex parte Quayle,* 1935 C.D. 1 1; 453 O.G. 213.

Disposition of Claims

☒ Claim(s) 19, 21-25 and 29-39 is/are pending in the application.

Of the above claim(s) _____ is/are withdrawn from consideration.

☐ Claim(s) _____ is/are allowed.

☒ Claim(s) 19, 21, 22, 25 and 29-39 is/are rejected.

☒ Claim(s) 23 and 24 is/are objected to.

☐ Claim(s) _____ are subject to restriction or election requirement.

Application Papers

☐ See the attached Notice of Draftsperson's Patent Drawing Review, PTO-948.

☒ The proposed drawing correction, filed on 4/18/2001 is ☒ approved ☐ disapproved.

☐ The drawing(s) filed on _____ is/are objected to by the Examiner.

☐ The specification is objected to by the Examiner.

☐ The oath or declaration is objected to by the Examiner.

Priority under 35 U.S.C. § 119 (a)-(d)

☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 11 9(a)-(d).

☐ All ☐ Some* ☐ None of the CERTIFIED copies of the priority documents have been

☐ received.

☐ received in Application No. (Series Code/Serial Number) _____.

☐ received in this national stage application from the International Bureau (PCT Rule 1 7.2(a)).

*Certified copies not received: _____.

Attachment(s)

☒ Information Disclosure Statement(s), PTO-1449, Paper No(s). 3

☐ Interview Summary, PTO-413

☒ Notice of References Cited, PTO-892

☐ Notice of Informal Patent Application, PTO-152

☐ Notice of Draftsperson's Patent Drawing Review, PTO-948

☐ Other _____

Office Action Summary

The following is a quotation of 35 U.S.C. 103(a) which forms the basis for all obviousness rejections set forth in this Office action:

> (a) A patent may not be obtained though the invention is not identically disclosed or described as set forth in section 102 of this title, if the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains. Patentability shall not be negatived by the manner in which the invention was made.

This application currently names joint inventors. In considering patentability of the claims under 35 U.S.C. 103(a), the examiner presumes that the subject matter of the various claims was commonly owned at the time any inventions covered therein were made absent any evidence to the contrary. Applicant is advised of the obligation under 37 CFR 1.56 to point out the inventor and invention dates of each claim that was not commonly owned at the time a later invention was made in order for the examiner to consider the applicability of 35 U.S.C. 103(c) and potential 35 U.S.C. 102(f) or (g) prior art under 35 U.S.C. 103(a).

Claims 19, 21 and 22 are rejected under 35 U.S.C. 103(a) as being unpatentable over Reid et al (6,074,544) in view of Wright, Jr. (4,563,399) and Chen (6,197,181).

The Reid et al patent is directed to a process for depositing a metal such as copper onto a semiconductor wafer. The wafer 36 is placed in plating apparatus opposite anode counter-electrode 67. A suitable copper plating bath contains 17

gm/l Cu^{++} ions, 170 gm/l H_2SO_4, 60 ppm Cl^- ions and an additive package (column 3, lines 52-54). Plating takes place over a thin seed layer which has a thickness of from 0.02 to 0.2 microns and may be applied by physical vapor deposition (column 1, lines 26-30) by applying a voltage between the wafer and anode 67 from power supply 65. Claim 19 differs from the process of Reid et al by reciting that the seed layer is cathodically polarized prior to or less than approximately 5 seconds following contact of the seed layer with the electroplating solution. As shown by Reid et al, a typical copper plating bath contains a significant amount of sulfuric acid. Such a bath is highly corrosive. The thin seed layer is vulnerable to etching and corrosion when immersed in the highly acidic copper plating bath. By beginning deposition as soon as possible, the thin seed layer is built up quickly. The technique of live entry, i.e., applying plating potential to the workpiece as it is immersed in the plating bath, is a recognized procedure as shown by Wright, Jr. See column 3, lines 43-45. Chen teaches that the copper deposition potential is in the range of -1.0 to -1.25 V (column 6, lines 29-33). Thus, to deposit copper, the seed layer is cathodically polarized as recited in claim 19. It would have been obvious at the time the invention was made to have cathodically polarized the seed layer by applying a cathodic copper plating voltage of about -1.0 volt, as taught by Chen, to the substrate of Reid et al as it is exposed to the plating solution by using the live entry technique, as taught by Wright, Jr., because deposition would have

begun immediately and corrosion of the seed layer would have been avoided. The anode serves as the counter-electrode recited in claim 20. Reid et al disclose that an initial current density of 5.25 mA/^{cm} was applied (column 4, lines 16-17). This value of current density falls at the upper end of the range recited in claim 22.

Claim 33 is rejected under 35 U.S.C. 112, second paragraph, as being indefinite for failing to particularly point out and distinctly claim the subject matter which applicant regards as the invention.

Claim 25 on which claim 33 ultimately depends, recites a step of applying a dc cathodic current having a second value of current density such that electroplating occurs preferentially on bottoms of recessed features having the least diffusion accessibility. Claim 33 recites that the second value of current density is between about 0 and about 5 mA/cm^2. This range appears to include zero. It is not clear how a current density of zero would be effective to cause the electroplating recited in claim 25. Additionally, it is noted that the range for the second value is essentially the same as that for the first value recited in claim 31. Since the first and second values of current density may be the same, it is not clear if there is any difference in the effect the application of the first and then the second current densities has on the substrate.

Claims 25, 29-31, 33 and 34 are rejected under 35 U.S.C. 103(a) as being unpatentable over Reid et al (6,074,544) in view of Wright, Jr. (4,563,399) and Chen (6,197,181).

Reid et al, Wright, Jr. and Chen are interpreted and applied as above. Claim 25 recites limitations similar to those of claim 19, and additionally recites the steps of applying a dc cathodic current having a first current density to create a conformal thin conductive metal film, contacting the thin metal film with the electroplating solution, applying a dc cathodic current having a second value of current density, increasing the current density, and further increasing the current density to a third value, filling the recesses. Claim 30 recites that the thin metal film has a thickness of about 500 Angstroms while claim 31 recites that the first current density is in the range from approximately 0.1 to approximately 5 mA/cm^2. Claim 33 recites that the second current density is in the range of about 0 to 5 mA/cm^2 and claim 34 recites that the third value of current density is between about 15 and 75 mA/cm^2. These additional limitations are considered to be suggested by Reid et al. Reid et al discloses a process in which the current density is initially applied at a low value and is then increased. In an operative example, the initial current density was 5.25 $mA/^{cm}$. This value of current density falls at the upper end of the range recited in claim 31. The initial current density was applied for 120 seconds (column 4, lines 16-17). Since the current density applied by Reid

et al falls within the range recited by applicant, the effect of the current density recited in instant claim 25 step 2 would have been expected to be the same. A period of 120 seconds would be expected to allow adsorption of the additive onto the thin conductive film as recited in claim 25, step 3. Reid et al disclose that the current density may be raised in one or more discrete steps or by ramping the current gradually upward. In addition, a combination of one or more steps and one or more ramps can be employed (column 2, lines 47-51). In the operative example, the current density was stepped upward to 47.25 mA/cm^2 (column 4, lines 18-19). This value falls within the range recited in instant claim 34 for the third value of current density. The current density of Reid et al must necessarily pass through the second value of current density recited by applicant, and the effect recited in claim 25 step 4 would be expected to be the same. As above, it would have been obvious at the time the invention was made to have cathodically polarized the seed layer by applying a copper plating voltage of about -1.0 volt, as taught by Chen, to the substrate of Reid et al as it is exposed to the plating solution by using the live entry technique, as taught by Wright, Jr., because deposition would have begun immediately and corrosion of the seed layer would have been avoided.

Claim 32 is rejected under 35 U.S.C. 103(a) as being unpatentable over Reid et al (6,074,544) in view of Wright, Jr. (4,563,399) and Chen (6,197,181) as applied

to claims 25, 29-31, 33 and 34 above, and further in view of Hubel (6,132,584).

Claim 32 recites that cathodic current pulses are superimposed on the first current density. Hubel is directed to a process of electroplating in which cathodic current pulses are superimposed in on dc cathodic current. See figure 1b and column 4, lines 35-40. It would have been obvious at the time the invention was made to have applied cathodic current pulses to the cathodic current of Reid et al as taught by Hubel because lower power loss resulting in a more efficient process would have been obtained.

Claim 35 is rejected under 35 U.S.C. 103(a) as being unpatentable over Reid et al (6,074,544) in view of Wright, Jr. (4,563,399) and Chen (6,197,181) as applied to claims 25, 29-31, 33 and 34 above, and further in view of Combs (4,272,335).

Claim 35 differs from the process of Reid by specifying that the additive comprises at least one chemical species that suppresses electroplating. Reid discloses that the bath contains the SELREX CUBATH M additive package but does not list the chemical composition of the additives. Combs is directed to copper electroplating and discloses useful additives for copper plating baths. One class of additives is polyethers. See column 5, lines 12-28 and Table I. These polyether compounds would function to suppress electroplating when adsorbed on the surface being plated. It would have been obvious at the time the invention was made to

have included a polyether in the additive package of Reid et al as taught by Combs because the properties of the deposit would have been improved.

Claims 36-38 rejected under 35 U.S.C. 103(a) as being unpatentable over Reid et al in view of Combs.

Reid et al is interpreted and applied as above. Claim 36 differs from Reid et al by specifying that the additive comprises a suppressive additive and an accelerating additive. Otherwise, claim 36 is similar to claim 25 except it does not require application of current within 5 seconds. As noted above, Reid discloses that the bath contains the SELREX CUBATH M additive package but does not list the chemical composition of the additives. Combs discloses the inclusion in a copper electroplating bath of polyether compounds which would function to suppress electroplating when adsorbed on the surface being plated. Combs further discloses the inclusion of sulfur compounds which would function as accelerator additives (column 5, line 63 - column 7, line 7). It would have been obvious at the time the invention was made to have included a polyether and a sulfur compound in the additive package of Reid et al as taught by Combs because the properties of the deposit would have been improved.

Claim 39 is rejected under 35 U.S.C. 103(a) as being unpatentable over Reid

et al in view of Combs as applied to claim 36-38 above, and further in view of Dubin et al ((5,972,192).

Claim 39 recites aspect ratios between 0.02 and 5.5. While Reid et al disclose depositing copper on a semiconductor surface which has narrow trenches and other circuitry features that must be completely filled without any voids (column 1, lines 21-25), the numerical values of the aspect ratios of the trenches is not given. The Dubin et al patent is directed to the electrodeposition of a metal such as copper into the features on the suface of a semiconductor. Dubin et al disclose that the aspect ratios of the features may be 2:1 to greater than 3:1 (column 3, lines 53-55). These values fall within the range recited in instant claim 39. It would have been obvious to have filled features with aspects ratios of 2:1 to greater than 3:1 in the process of Reid et al because such features are commonly used as shown by Dubin et al.

The prior art made of record and not relied upon is considered pertinent to applicant's disclosure. Landau et al discloses that sulfuric acid in copper plating baths cause copper dissolution (column 4, lines 10-17)

Claims 23 and 24 are objected to as being dependent upon a rejected base claim, but would be allowable if rewritten in independent form including all of the limitations of the base claim and any intervening claims. The prior art of record

does not suggest that the polarization of the seed layer should be performed by applying a net cathodic voltage to the seed layer with respect to a copper reference electrode prior to contacting the electroplating solution as recited in claim 23. The reference electrode is considered to be different than the anode counter-electrode disclosed by Reid et al.

Any inquiry concerning this communication or earlier communications from the examiner should be directed to William Leader, whose telephone number is (703) 308-2530. The examiner can normally be reached Mondays-Fridays from 7:30 AM to 3:30 PM eastern time.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Kathryn Gorgos can be reached at (703) 308-3328. The fax phone number for *official* after final faxes is (703) 872-9311. The fax phone number for all other *official* faxes is (703) 872-9310. Unofficial communications to the Examiner should be faxed to (703) 305-7719.

Any inquiry of a general nature or relating to the status of this application should be directed to the receptionist whose telephone number is (703) 308-0661.

William Leader:wtl
December 13, 2001

DONALD R. VALENTINE
PRIMARY EXAMINER
GROUP 1100 1741